

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, DC**

*In the Matter of*

Spectrum Policy Task Force Seeks  
Public Comment on Issues Related to  
Commission's Spectrum Policies

DA 02-1311  
ET Docket No. 02-135

## **Comments of Kevin Werbach**

### **Introduction and Summary**

The Commission is to be commended for forming a Spectrum Policy Task Force, and for initiating a comprehensive review of its spectrum policies. The issues raised in the public notice<sup>1</sup> are of the utmost importance. Spectrum represents a tremendous and under-utilized resource for delivering voice, rich media and data communications services to all Americans.

Technological advances in recent years have made it possible to share the radio spectrum as a “commons,” without exclusive licensing. This allows for a new policy approach, known as open spectrum. Open spectrum could further the Commission's mandate to promote competition, deregulation, innovation, investment and the public interest. Yet the Commission lacks the wherewithal to appreciate open spectrum's potential, because its policy framework dates from the early days of the previous century.

It is time to rethink old assumptions. The Commission should use this opportunity to examine, publicize and ultimately promote open spectrum.

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<sup>1</sup> Spectrum Policy Task Force Seek Public Comment on Issues Related to Commission's Spectrum Policies, Public Notice, ET Docket No. 02-135, DA 02-1311 (June 6, 2002).

Specifically, the Commission should:

- Move expeditiously to remove barriers to deployment and use of unlicensed wireless technologies, including but not limited to IEEE 802.11 protocols operating in the 2.4 GHz and 5 GHz bands and ultra-wideband;
- In consultation with other relevant agencies and the private sector, identify additional spectrum bands that can be designated for unlicensed use;
- Develop an “Intelligent Radio Bill of Rights” and equipment-certification rules defining the privileges and responsibilities of smart devices communicating over the airwaves, to create incentives for efficient cooperative use of unlicensed spectrum.

I am participating in this docket as an independent technology analyst and consultant. From 1994 to 1998, I served as an attorney and Council for New Technology Policy at the Commission. Subsequently, I analyzed developments in wireless and other emerging technologies as editor of *Release 1.0: Esther Dyson's Monthly Report*. I have not been retained by any client to prepare these comments.

### **The Open Spectrum Opportunity**

In the *Computer Inquiries* of the 1970s and 1980s, the Commission put into place a set of policies that set the stage for the emergence of the commercial Internet, producing massive social and economic benefits.<sup>2</sup> A similar opportunity exists today with spectrum.

Technology and market conditions have created a new environment, in which users can share spectrum without licensing. New unlicensed devices could undermine the foundations of the current regulatory paradigm as surely as did the appearance of computers in the Bell System's telephone network. Put simply, it is now possible to treat spectrum bands as “commons,” available to all. This approach, known as “open spectrum,” turns the traditional licensing model on its head.<sup>3</sup>

If allowed to develop, unlicensed technologies will allow for more efficient and creative use of the precious resource of the airwaves. Because it challenges traditional approaches and does away with expensive exclusive licensing, however, open spectrum may threaten incumbents who are comfortable with the status quo. The Commission should reaffirm its allegiance to markets rather than individual competitors within them, and place itself squarely on the side of innovation.

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<sup>2</sup> See Jason Oxman, *The FCC and the Unregulation of the Internet*, Office of Plans and Policy Working Paper No. 31 (July 1999), available at [http://www.fcc.gov/Bureaus/OPP/working\\_papers/oppwp31.pdf](http://www.fcc.gov/Bureaus/OPP/working_papers/oppwp31.pdf).

<sup>3</sup> See, e.g., Kevin Werbach, “Open Spectrum: The Paradise of the Commons,” *Release 1.0*, November 2001, available from the author or at <http://www.release1-0.com>); Yochai Benkler, “Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment,” 11 *Harvard Journal of Law and Technology* 287 (1998), available at <http://www.law.nyu.edu/benklery/agoraphobia.pdf>.

The comments below offer specific arguments and recommendations in favor of open spectrum. At the very least, the Spectrum Policy Task Force should use its present effort to explore the feasibility and potential of this approach. Doing so poses no risks and could generate substantial benefits. A commitment to open spectrum is not inconsistent with most initiatives to promote flexibility and market-oriented spectrum policy. Unlicensed and licensed bands can continue to coexist.

The Task Force should invite representatives from the private sector and the technical community involved in the development of unlicensed devices to participate in its workshops. It should acknowledge that unlicensed uses represent a significant and growing market segment. And it should include open spectrum as a substantial component of its report to the Commission. If the private sector sees that the Commission recognizes the potential of open spectrum, it will invest in overcoming technical hurdles around issues such as price, reliability, security and quality of service.

## **Responses to Specific Questions in the Public Notice**

### Questions 1-4 (Market-oriented Allocation and Assignment Policies)

In examining “market-oriented” allocation and assignment policies, the Commission should not limit itself to the economic mechanisms that phrase traditionally connotes: auctions, flexible use, secondary markets and privatization. Greater flexibility for licensees, so that incentives exist for spectrum to be put to its highest and best use, would be worthwhile. But the most significant example of market-driven creation of new services using the radio spectrum has nothing to do with FCC license terms or assignment mechanisms. The real market-oriented activity today is taking place in the unlicensed bands.

As it develops its policy recommendations, the Spectrum Policy Task Force should take a close look at the recent history of WiFi (IEEE 802.11b) and related wireless LAN technologies.<sup>4</sup> From a standing start in 1999, the WiFi market has grown into a substantial business, with expected sales of more than 10 million PC/laptop adapter cards this year. Thousands of “hotspots” have been established in coffee shops, airports, hotels and other public locations throughout the country. Major corporations and educational institutions have deployed wireless networks across their campuses, giving employees or students ubiquitous unfettered Internet access. Vendors such as Cisco, Linksys, Intel, D-

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<sup>4</sup> WiFi is a marketing and certification term promulgated by the Wireless Ethernet Compatibility Alliance, an industry trade group. It refers to the 802.11b wireless Ethernet standard defined by the Institute for Electrical and Electronic Engineers (IEEE). It operates in the 2.4 GHz Industrial, Scientific and Medical (ISM) band, and delivers up to 11 megabits per second connections within a local area. Related standards include 802.11a (WiFi5), which operates in the 5 GHz U-NII band and offers speeds up to 54 megabits per second; 802.11g, which delivers higher-speed connections in the 2.4 GHz band; and 802.11e, which adds quality-of-service mechanisms to support high-quality voice and video delivery. Standards work in this area is ongoing.

Link, Netgear and Proxim are doing a brisk business selling access points for home networks, adding value to residential broadband connections.

Few of these applications were envisioned when the 802.11b standard was formalized. Fewer still were on anyone's mind when the Commission set aside the 2.4 GHz band for unlicensed use. Because it uses unlicensed spectrum, WiFi must contend with other uses in the same band, but that hasn't stopped the market from growing. Instead, the fact that the unlicensed bands are shared has actually promoted innovation, leading vendors to develop smarter devices and creating a fertile ground for experimentation that cannot take place in licensed bands.

WiFi isn't the only promising unlicensed wireless technology. Startups such as Etherlinx have developed proprietary systems that 802.11b radios for long-range high-speed connectivity, appropriate for broadband last-mile applications. Several companies including Nokia (with its Rooftop system), Mesh Networks and SkyPilot offer unlicensed systems using a meshed topology, meaning that each node on the network communicates with other nearby nodes rather than a central hub. The IEEE is developing standards, 802.16, for metropolitan-area wireless networks using 10 GHz - 66 GHz spectrum. And the Commission recently authorized limited commercial deployment of ultra-wideband technology, which uses such low power that it can overlay on existing licensed spectrum.<sup>5</sup>

In thinking about rule changes "to migrate from current spectrum allocations to more market-oriented allocations," the Commission should exercise care not to preclude further growth of market-oriented, bottom-up unlicensed technologies. A remarkable aspect of these technologies is that they can share the same spectrum, using digital signal processing and modulation techniques to decipher independent signals.

The traditional licensing model assumes that spectrum is scarce, and must be carefully partitioned and handed out to companies best able to make use of it. Open spectrum turns that model on its head. Sharing means that spectrum is less scarce than it previously seemed. The smarter the devices, the more virtual spectrum they can create from the same range of frequencies. And if devices use cooperative techniques such as repeating each other's signals, the information-carrying capacity of a given spectrum band can actually *increase* with more transmitters.<sup>6</sup> Open spectrum allows for novel architectures, such as *ad hoc* device-to-device networks, going beyond the centralized models we have long taken for granted.

All this, however, requires that spectrum be available for shared, unlicensed use. The more spectrum the Commission licenses exclusively, the less room there is for breaking the scarcity bottleneck. Giving licensees greater flexibility, and ultimately ownership

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<sup>5</sup> See Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, ET Docket No. 98-153, First Report and Order, FCC 02-48 (February 14, 2002).

<sup>6</sup> See, e.g., Tim Shepard, "Decentralized Channel Management in Scalable Multihop Spread-Spectrum Packet Radio Networks," MIT dissertation (1995), available at <ftp://ftp.lcs.mit.edu/pub/lcs-pubs/tr.outbox/MIT-LCS-TR-670.ps.gz> (describing one scalable architecture).

over the spectrum they control, could lead to the creation of private unlicensed “spectrum parks,” but is more likely to shut out shared usage. Companies that pay for spectrum licenses have incentives to keep that spectrum to themselves rather than allow in additional competitors, even if competition would maximize social welfare.

Flexibility *per se* is not the problem. So long as the Commission makes enough spectrum available for unlicensed use, with the characteristics necessary for exploitation by the private sector, flexibility within the licensed bands would be beneficial.

#### Question 5 (unlicensed operations)

The Commission should identify additional spectrum bands that can be designated for unlicensed use, in consultation with other relevant agencies and the private sector. WiFi took hold in a narrow spectrum band already crowded with other users, because that was the best unlicensed spectrum available. Scaling up unlicensed services to larger numbers of users, longer range and higher speeds may tax the limits of the unlicensed bands that exist today. Finding and setting aside additional unlicensed bands should be a central element of the Commission’s spectrum policies.

New unlicensed spectrum may not immediately lead to a burst of deployment comparable to the WiFi boom of the past three years. After all, the 2.4 GHz and 5 GHz bands were around for several years before WiFi came along. The benefits of providing more spectrum for unlicensed use will be felt over time. The result will be similar to the pro-competitive and pro-innovation benefits of the Commission’s forward-looking decision in the *Computer Inquiries* to wall off enhanced services and enhanced service providers from unnecessary regulation and potential anti-competitive actions of dominant carriers. If, however, the Commission does *not* act today to facilitate a spectrum commons, it may close off irreplaceable opportunities in the future.

There are many possible sources for additional unlicensed spectrum. The reality is that most of them will involve relocation or other accommodation of existing users, but that is a process the Commission has engaged in repeatedly in the past. The forthcoming return of analog television spectrum and the need to allocate spectrum for third-generation cellular (3G) provide a unique opportunity to identify a portion of spectrum and set it aside as a commons.

In seeking to allocate additional spectrum for unlicensed use, the Commission should not limit itself to frequency bands previously designated for commercial use. The Commission should consult with other relevant agencies, including the National Telecommunications and Information Administration of the Department of Commerce and the Department of Defense, to identify other bands that could be reclassified from exclusive government, military or public safety use to a spectrum commons. The Commission should submit a report to the Congress identifying any possibilities for additional unlicensed spectrum that would require Congressional action.

The Commission should also work closely with the private sector and the technical community to ensure that unlicensed spectrum is actually useful and usable. Groups such as the IEEE are responsible for defining the standards that will be important to adoption of any new unlicensed technology. Organizations such as the National Academy of Sciences may be in a position to offer broad technical guidance on potential unlicensed uses and the kinds of spectrum they require. Existing vendors of unlicensed wireless equipment, which includes major industry players such as Intel, Microsoft, Cisco and IBM, should be encouraged to contribute to the discussion. In particular, the Commission should ask these vendors to indicate, wherever possible, the specific uses and markets they envision for any new unlicensed spectrum.

Question 5 also asks, “Because of the commons aspects of unlicensed use, is there concern that, as congestion rises, spectrum may not be put to its highest valued use?” I respond to this question below in the section on interference.

#### Question 6 (experimentation)

The Commission should encourage the private sector to make greater use of the experimental licensing and developmental authorizations that exist. Academic researchers, small companies and individuals are not likely to be aware of the freedoms that already exist to investigate new wireless technologies. The Task Force should use its Website and its forthcoming workshops to publicize the process and the availability of such experimental options.

Furthermore, a strong public commitment by the Commission to open spectrum generally, and to facilitating deployment of new unlicensed technologies specifically, would make experimental options more attractive. Companies today are often hesitant to expend the resources for an experimental, developmental or demonstration project, because they believe the Commission will not approve commercial deployment.

#### Questions 7-21 (“Interference”)

The very term “interference” in connection with the radio spectrum is misleading. At the relevant frequencies, radio waves do not bounce off or absorb one another. The electromagnetic radiation from one transmitter passes through the “interfering” radiation from another transmitter. What changes is that it becomes more difficult for receivers to disentangle the signals from one another, and from background noise. “Interference,” therefore, is a function of receiver design, which is governed by the Commission’s rules. The classic example is UHF television, which requires large guard bands even today because the Commission in the 1950s adopted a lax standard for TV receivers.

“Interference” is a function of the time span under consideration, and of the architecture of the network. Higher power allows for longer-range transmissions, but has the effect of drowning out other signals. Wider bandwidth can increase “interference” if every signal

attempts to occupy the entire frequency band, but it *decreases* interference when spread-spectrum or ultra-wideband techniques are used. With these approaches, the wider bandwidth creates more shared territory for different users to coexist.

Finally, if every transmitter and receiver is ignorant of other users, those other users are by definition “interference.” But if receivers automatically sense and adapt to the local spectral environment before transmitting, or if they cooperatively relay traffic to other receivers, the picture is quite different.

Existing definitions of “interference” and “harmful interference” assume an exclusive, licensed model for spectrum. The question in the public notice is like asking how many people can talk simultaneously in a crowded room. If everyone is yelling, any additional speaker will decrease the ability of *everyone* to hear. This is the “tragedy of the commons” the public notice alludes to in Question 5. But the tragedy need not occur. If everyone in the room whispers, far more simultaneous conversations are possible. If people can pass messages across the room on pieces of paper, the number increases even more.

The relevant question, then, is not whether “as congestion rises, spectrum may not be put to its highest valued use,” or how “interference” should be defined. The question is how to craft rules for both licensed and unlicensed bands that expand the carrying capacity of spectrum. When a band is given to a licensee, any other use that prevents that licensee from delivering the desired service is “harmful interference.” But if additional communications can be achieved in that band without harming the licensee, as is the case with ultra-wideband, the same frequency range has suddenly become more valuable.

The traditional concepts of “congestion” and “interference” are even less appropriate for the unlicensed bands. In a spectrum commons, every user has incentives to use spectrum wisely and intelligently, because it has no guarantee of protection against competing uses. In contrast to licensed bands, where manufacturers have incentives to make devices dumb in order to reduce costs, manufacturers in unlicensed bands must find clever ways to communicate in an uncertain environment. There are several technical means of doing so, including spread-spectrum technologies and agile radios able to adapt to a changing RF environment.

The success of WiFi shows that spectrum sharing works in the real world. Despite repeated warnings of a “meltdown,” only isolated anecdotal cases of congestion among WiFi users have been reported. Moreover, wireless LAN technology is evolving and diversifying rapidly. For example, vendors are beginning to deliver hybrid 802.11a/b/g chipsets, and devices that can roam between WiFi and wide-area GSM/GPRS cellular networks are coming on the market. As more access points spring up, the average range of connections can become shorter, reducing the possibility of “interference.” Companies such as Intel and Microsoft are devoting substantial resources to these technologies, which they would be unlikely to do if they were seriously concerned about a tragedy of the commons.

WiFi is far from perfect. Now that it and its sister wireless LAN protocols have taken off in the market, the Commission should undertake a thorough review of its Part 15 and other rules to determine whether changes in the 2.4 GHz and 5 GHz bands could allow for more efficient shared use of the spectrum. The Commission should identify and remove any barriers that exist to continued deployment of unlicensed devices, whether originating from its own rules, other government agencies, or private-sector actions.

As noted above, network architecture has a significant effect on spectral efficiency. Open networks in unlicensed bands create a multiplier effect, because each new network node grows the network for everyone. It is this phenomenon of open standards and interconnection that allowed the Internet to become the vehicle of innovation and economic activity that it represents today. (And, it should be noted, many also predicted that the Internet would be unable to scale and would melt down as usage increased.) The Commission should therefore take whatever steps it can to promote open platforms in existing unlicensed bands, and to factor in the benefits of cooperative networking in defining requirements for new unlicensed bands.

Specifically, the Commission should develop an “Intelligent Radio Bill of Rights”<sup>7</sup> and equipment-certification rules defining the privileges and responsibilities of smart devices communicating over the airwaves, to create incentives for efficient use of unlicensed spectrum. Whether this Bill of Rights represents merely recommended “best practices” or mandated technical conditions for devices, it should be developed in consultation with the private sector and technical experts. It may not be possible to predict ahead of time the most efficient architecture for use of shared wireless spectrum. But a Bill of Rights and other regulatory actions could create incentives for market participants to find the best solution.

## **Conclusion**

For seventy years, the Commission has operated under the assumption that spectrum is a scarce resource. Because spectrum is scarce, it must be carefully partitioned out to specific licensees, who can prevent others from making use of those bands. Because spectrum is scarce, it is expensive... so companies must expend substantial resources to pay for it, even before deploying services. Because spectrum is scarce, it must be tightly regulated, to a degree we would not normally tolerate for a resource so connected to speech. Because spectrum is scarce, market forces of competition and innovation cannot fully function within its confines.

Spectrum need not be scarce.

Because spectrum can now be shared efficiently, the entire playing field changes. The Commission’s policies should reflect the technical realities of 2002, not 1934. Just as, in the *Computer Inquiries*, the Commission acknowledged and grappled with the

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<sup>7</sup> The term comes from former Disney Imagineering executive Bran Ferren, who proposed the concept to the FCC’s Technological Advisory Council.



tremendous implications of computing on the telephone network, it should recognize that its spectrum policy framework is based on outdated assumptions.

Beginning with this proceeding and the related activities of the Spectrum Policy Task Force, the Commission should facilitate the continued growth of unlicensed wireless technologies. It should put itself squarely on the side of open spectrum, which promises a newfound abundance that will deliver great benefits to the American people.

Respectfully submitted,

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